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ABSTRACT

This report deals with the developmental history of the Intermediate Science Curriculum Study (ISCS). Description of the project and its origins as well as summative evaluation are briefly discussed. Diffusion of the project and subsequent adoption are treated and its future potential evaluated. (CP)

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PRODUCT DEVELOPMENT REPORT NO. 3

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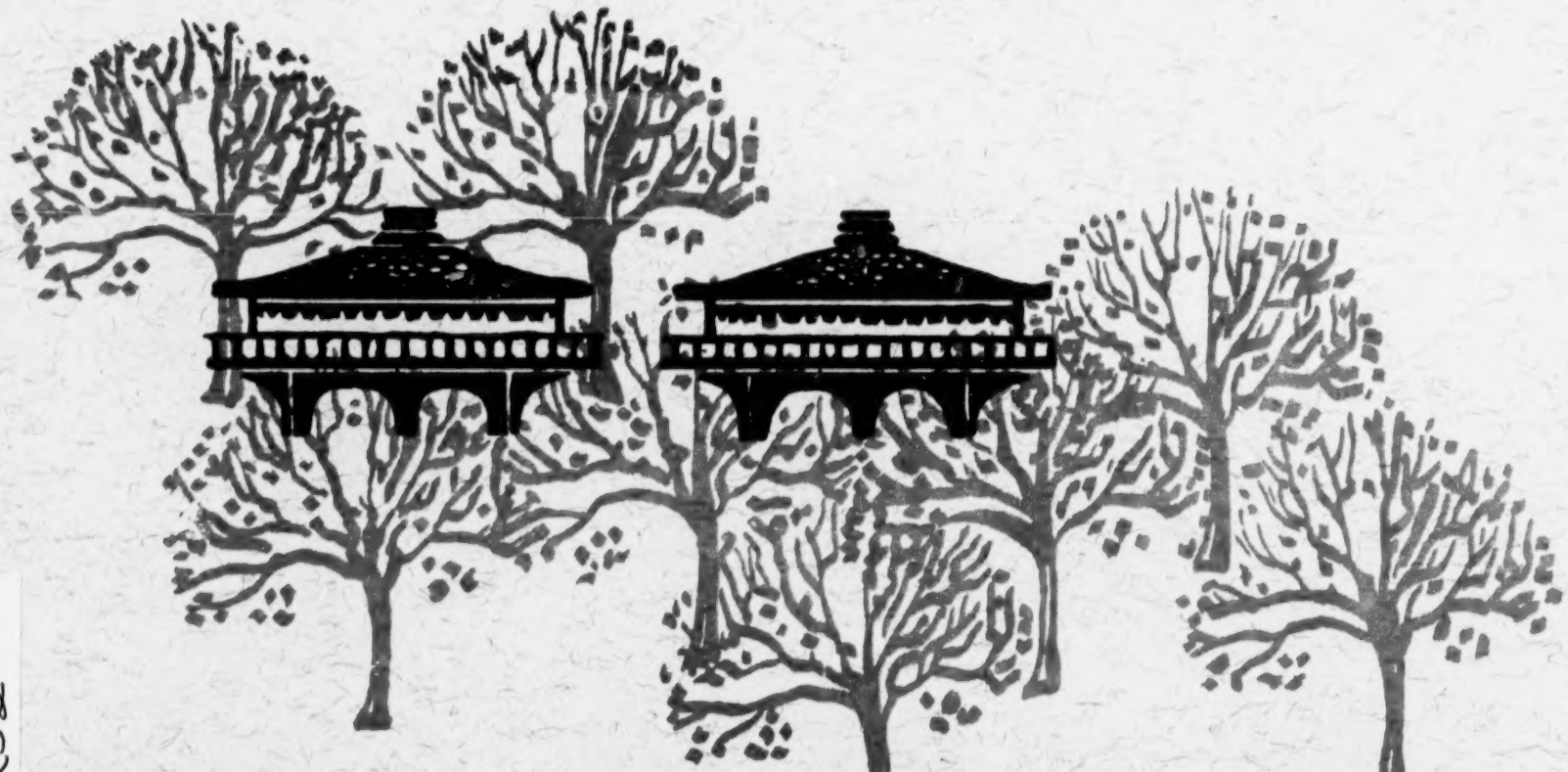
INTERMEDIATE SCIENCE CURRICULUM STUDY

DEVELOPED BY THE FLORIDA STATE UNIVERSITY

INTERMEDIATE SCIENCE CURRICULUM STUDY PROJECT

November, 1971

Contract No. OEC-0-70-4892



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Daniel W. Kratochvil
Jack J. Crawford

American Institutes for Research
in the Behavioral Sciences

Palo Alto, California

November, 1971

The research reported herein was performed pursuant to a contract with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Office of Program Planning and Evaluation

PREFACE

This product development report is one of 21 such reports, each dealing with the developmental history of a recent educational product. A list of the 21 products, and the agencies responsible for their development, is contained in Appendix A to this report. The study, of which this report is a component, was supported by U.S. Office of Education Contract No. OEC-0-70-4892, entitled "The Evaluation of the Impact of Educational Research and Development Products." The overall project was designed to examine the process of development of "successful educational products."

This report represents a relatively unique attempt to document what occurred in the development of a recent educational product that appears to have potential impact. The report is based upon published materials, documents in the files of the developing agency, and interviews with staff who were involved in the development of the product. A draft of each study was reviewed by the developer's staff. Generally, their suggestions for revisions were incorporated into the text; however, complete responsibility for interpretations concerning any facet of development, evaluation, and diffusion rests with the authors of this report.

Although awareness of the full impact of the study requires reading both the individual product development reports and the separate final report, each study may be read individually. For a quick overview of essential events in the product history, the reader is referred to those sections of the report containing the flow chart and the critical decision record.

The final report contains: a complete discussion of the procedures and the selection criteria used to identify exemplary educational products; generalizations drawn from the 21 product development case studies; a comparison of these generalizations with hypotheses currently existing in the literature regarding the processes of innovation and change; and the identification of some proposed data sources through which the U.S. Office of Education could monitor the impact of developing products. The final report also includes a detailed outline of the search procedures and the information sought for each case report.

Permanent project staff consisted of Calvin E. Wright, Principal Investigator; Jack J. Crawford, Project Director; Daniel W. Kratochvil, Research Scientist; and Carolyn A. Morrow, Administrative Assistant. In addition, other staff who assisted in the preparation of individual product reports are identified on the appropriate title pages. The Project Monitor was Dr. Alice Y. Scates of the USOE Office of Program Planning and Evaluation.

Sincere gratitude is extended to those overburdened staff members of the 21 product development studies who courteously and freely gave their time so that we might present a detailed and relatively accurate picture of the events in the development of some exemplary educational research and development products. If we have chronicled a just and moderately complete account of the birth of these products and the hard work that spawned them, credit lies with those staff members of each product development team who ransacked memory and files to recreate history.

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PRODUCT DESCRIPTION

Product Characteristics

Name

This product is known by two names: Probing the Natural World and Intermediate Science Curriculum Study. The former is the name given to the product by the commercial publisher, and the latter is the name used by the developers.

Developer

The developer was the Intermediate Science Curriculum Study Project at Florida State University.

Distributor

Silver Burdett Company, a division of General Learning Corporation, was selected in 1969 to publish the ISCS text materials. The manufacturer of the ISCS laboratory equipment is Damon/Educational Division, which has worked with ISCS since 1967. All materials and laboratory equipment can be ordered from Silver Burdett. The format for the commercial edition is similar to the developmental editions, insofar as economic considerations and state adoption specifications permitted.

Focus

Probing the Natural World is an individualized science program which focuses on both the content and processes of science.

Grade Level

Grades 7-9.

Target Population

The target population consists of all junior high school students in grades 7-9. The program was designed for students of varying ability and provides separate routes that students can follow and the opportunity for each student to work at his own pace. Since the major format is the printed page, students with severe reading disabilities have had difficulty; however, the pictorial activity frames in the texts have aided the poor reader, implying that he may have done more poorly in a science program using typical textbooks.

Rationale for Product

Long Range Goals of Product

The ISCS Project was organized to plan, develop, and implement a system of individualized instruction in science that could be used today by most teachers in typical schools. This system has focused on science instruction for grades 7 through 9. Presently, the seventh grade program is commercially available; the eighth grade program will be commercially available in the fall of 1971; and the ninth grade program will be completed in the fall of 1971 and commercially available in the fall of 1972. The developers feel that the long range goal of filling a gap between elementary and high school instruction in science will be reached. According to the developers, the most significant activity given impetus by this effort has been the development of teacher training materials that could be adapted to individualized educational settings at all grade levels, K-12; and for all content areas. The developers believe these training materials will be appropriate for language, mathematics, and social studies, as well as the physical sciences.

Objectives of Product

The ISCS aims at giving the junior high school student a general education in science that is applicable to the wide diversity of school and life situations. The student using the materials should gain a valid understanding of what science is and how scientific knowledge is obtained. At the same time, he should learn scientific concepts and skills to help him interpret both natural phenomena and technology in his own environment. By facing reasonably significant questions and working out ways to attack them, the developers hope that students will be able to acquire a repertoire of ideas and intellectual skills that will permit them to engage in productive inquiry.

Performance objectives have been written for the seventh, eighth, and ninth grade courses; these objectives served as the basis of the self-evaluation program. However, two limitations should be pointed out. First, the developers have stated that these objectives do not exhaust all the cognitive and affective goals that ISCS writers aimed at or that are probably accomplished by the materials. Second, objectives were developed for ISCS in-house use with the understanding that they would be available to the user at a later date, after refinement. The behavioral objectives do not

appear in the commercial editions that are now available; while the publisher indicated in its early brochures that the behavioral objectives were noted in the teacher's edition of the text, they are still waiting for the list of objectives from the developers. Presently, statements of general purposes preceed each chapter in the teacher's edition.

Philosophy Behind Product

The generalized goal of the ISCS project was to introduce individualized instruction into the science classes of the nation's junior high schools. This goal was based upon the assumption that tailoring instruction to the needs of the individual is more likely to stimulate effective learning than is the more general practice of allowing all of the students in a class to experience essentially the same instruction. To those who planned the ISCS program, instruction could be described as being individualized if both the rate at which the material was covered and the scope and sequence of the topics dealt with varied depending upon the needs of individual students. The principal thrust of the ISCS project was to design a set of materials that would enable the average teacher to build these two concepts into his teaching.

Although the idea of individualizing instruction was certainly not new, the ISCS staff recognized that the concept of individualization had little direct impact upon educational practice. They believed that the primary factor holding back individualized instruction had been the lack of a plan for teaching in this way--a plan that took into consideration such factors as the realities of school financing and construction, the capabilities and training of present teachers, the number and diversity of the students that must be taught, the limitations imposed by state regulations and laws related to education, and the kinds of pressures that are applied to school administrators. Early models for individualization had been tested under idealized conditions and broke down when they were exported to the real world. The question that was constantly before those who conceived the ISCS scheme for instruction and those who developed the ISCS materials was, "Will it work in the average classroom?"

Theories Supporting Product

One of the key premises of the program is the assumption that most students undergo an extensive cognitive transition between the seventh grade

and the ninth grade. While the average seventh grade students are able to give structure to the things they encounter, they are not readily able to deal with possibilities not directly before them or not already experienced. They cannot go systematically beyond the information given to a description of what else might occur. Piaget characterized this former mode of thought as the "stage of concrete operations." The ISCS materials were designed to help the student make the transition from that concrete operational stage to a stage in which he is quite able to operate on a hypothetical proposition rather than being constrained to think of what he has actually experienced or what is before him. This new stage Piaget called the "formal operational stage." In short, the developers claim that the ISCS materials are designed to help the student think more abstractly.

The developers have identified several aspects of ISCS designed to help the student make the transition from concrete to abstract thinking. Most of the initial learning activities require the student to handle concrete objects. The sequence of content built into the three year program was selected with the thought of postponing the introduction of more abstract and global conceptions, and those concepts that are not easily demonstrated with physical objects. The seventh grade course tends to focus upon questions that involve manipulating uncomplicated concrete objects while the problems posed in grade 9 tend to deal with fairly complex situations. Finally, to facilitate the "disequilibration" that Piaget considers essential in making the transition from concrete operational thinking to formal operational thinking, the materials put the student into problematic situations for which he must find rational explanations.

According to the developers, several other key assumptions were made. Many students at these grade levels are limited in their ability to apply arithmetic skills and to comprehend complex printed materials. In ISCS, considerable effort was put into finding better ways to communicate via the printed page than the ones used in traditional junior high school science textbooks. No activity included in the program calls for the use of arithmetic skills at a higher level than addition, subtraction, multiplication, and division. The belief that reinforcement is essential for effective learning and that knowledge often tends to be hierarchical, played a heavy role in determining the content sequence. No concept or notion was introduced that was not reinforced by subsequent use, and effort was made to

avoid dealing with complex topics before dealing with simpler concepts encompassed.

Description of Materials

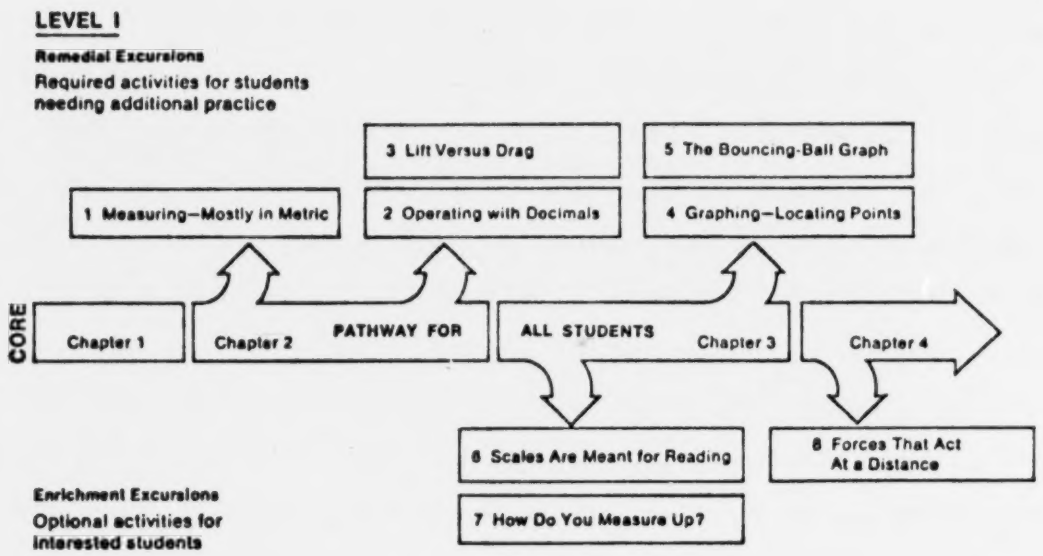
Organization of Materials

To provide for individual differences in students' learning rates and to help each student evaluate his own progress, ISCS text materials include the following components. All students, regardless of interest, ability or background, are exposed to sequenced series of core activities which cover the essential content of the course of each grade. Each student proceeds through these "core activities" at his own pace and all students are not expected to finish the same number of activities at the same time. "Excursions" are activities which are departures from the core and which provide greater challenge for the more apt student and remedial help for the less able. The developers pointed out that each student can have a multi-track program specifically geared to his needs. There are about equal amounts of core and excursion materials at each grade level. Self-tests, based upon behavioral objectives established by ISCS, are taken by the student upon his completion of each core chapter and provide him with evidence of his own progress. They help him to identify his errors and to correct them by himself.

Various devices lead the student to excursions. Periodically, he encounters a "checkup frame." If he performs the skills in the frame, he moves on; if not, he goes to an excursion. At other points the student simply encounters references to excursions, some remedial, some extensions of new concepts. The student decides whether he should take these excursions. Finally, the teacher may recommend that the student take an excursion. The figure on the following page illustrates the tracking of some core activities and excursions.

Figure 1

The Tracking of Some Core Activities and Excursions



Format of Materials

The printed page was chosen as the primary vehicle for communicating with a student. A more audiovisually oriented approach that would reduce reading problems was rejected because of the increased cost. Developers decided to live with the problems inherent in the use of printed materials rather than to risk the possibility that large numbers of schools might reject the program because its costs were too high. The language used and the design of the printed materials were selected to promote readability. Tone, layout of pages, and the use of illustrations were developed through a process of tryout and evaluation rather than as the result of a single decision.

The materials at each of the three grade levels, in their commercial version, consist of four texts and laboratory materials. The main text is a non-expendable hardback student textbook divided into two distinct sections. The first section contains the basic materials that make up the core; the second section contains all the excursions. The second hardback text is the teacher's guide, which is an annotated student's text, including all the material in the student's book, equipment lists, helpful hints,

answers to key questions and teaching strategies. A front section provides an overview and the rationale of ISCS, and detailed information and guidance on such subjects as maintaining an individual classroom, testing and grading.

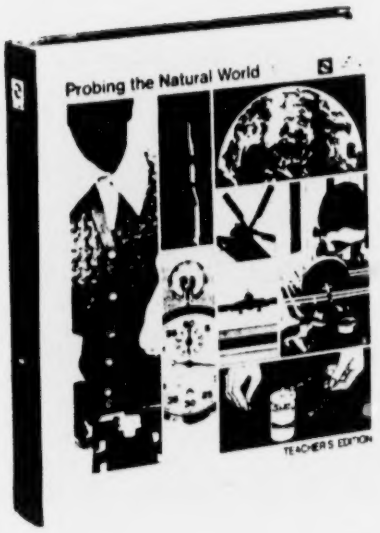
In addition to these two hardback texts, there are two softcover books, one for the student and one for the teacher. One of these is the Student Record Book, which is divided into four parts. The first two sections provide spaces for the student to record his answers to all questions posed in the chapters and the excursions. Tables, figures, and grids for graphs occur sequentially, just as they do in the main text, but are enlarged so data can be entered on them. The next section of the Student Record Book consists of "self tests," short evaluation tests that each student completes after he finishes each of the chapters. The final section contains suggested answers for the self tests and recommendations for review. The second softcover book is the teacher's edition of the Student Record Book, which contains all the material in the student's edition and includes suggested answers for questions, typical graphs, and completed tables. For the self tests, there is advice regarding advance planning and teacher assistance. The laboratory materials reach the classroom in packages that are suitable for use as classroom storage units. A numbered inventory of contents is printed on each carton. The laboratory packages include all the materials necessary to accommodate recommended classroom activities. Each master set or package serves one teacher and 30 students. Figure 2 shows the student text, a laboratory package, and a page from the student text.

Content of Materials

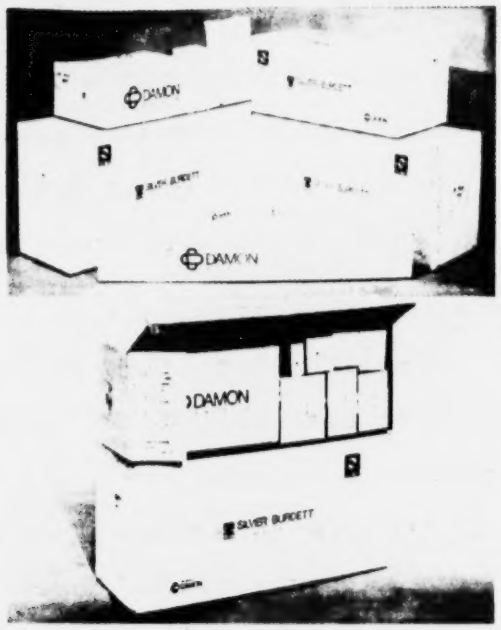
The ISCS curriculum includes the subject matter and the processes of science; both receive an integrated parallel development. The process and content of science are dealt with simultaneously in the materials by allowing concepts to arise out of investigation. The rationale for the subject matter sequence of the three-year program is that concepts of physics provide a functional base for those of chemistry and that a study of principles of both chemistry and physics should precede investigations of the life and earth sciences. Figure 3, on pages 10 and 11, diagrams the overall flow of content and process across the three grade levels, describes the organizing themes, and notes the concepts at each grade level.

Figure 2

Format of Materials



Student Text



Laboratory Equipment

Figure 2 (Continued)

Format of Materials

ACTIVITY 11-2. Hold the string and remove the book. Now add sinkers to the cup until the weight just holds the cart in place.

When you have added the proper number of sinkers, a gentle push should move the cart up the plane at a constant speed. But it should *not* move without a push.

ACTIVITY 11-3. Weigh the cup and sinkers with your force measurer. This weight is the force required to just pull the cart up the plane. Enter this force in Table 11-1 of your Student Record Book.

Table 11-1

Trial	Height of Plane (in cm)	Force on Cart (in newtons)
1		
2		
3		
4		
5		
6		

The cart weighs 500 g (0.5 kg), and the length of the plane is 122 cm. You will keep these two factors constant. The height of the plane and the force needed to pull the cart up the plane are variables. You will vary the height of the plane and measure the new pulling force needed to move the cart each time.

Page of Text

Figure 3

Flow of Content and Process Across Grade Levels

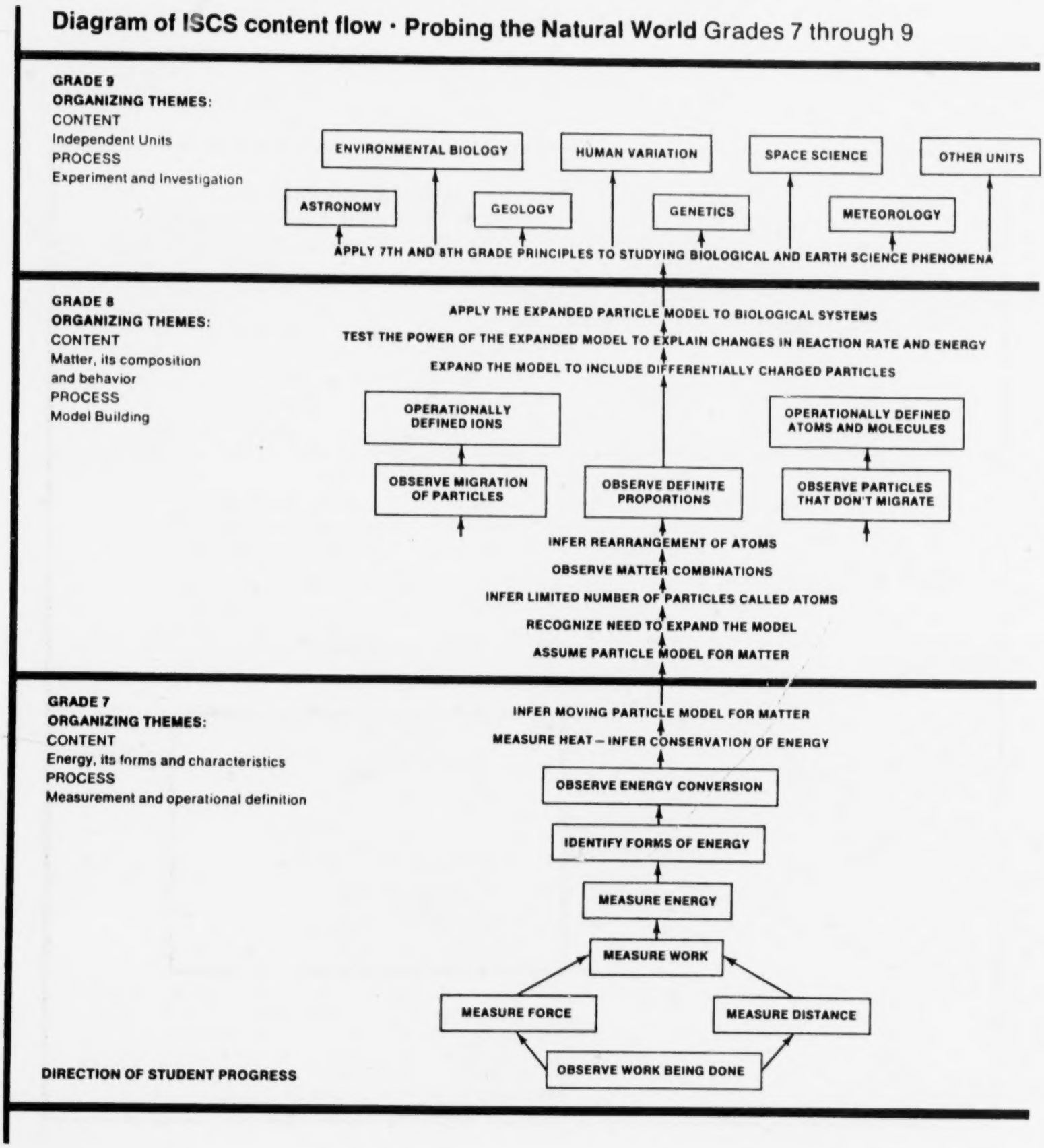


Figure 3 (Continued)

Flow of Content and Process Across Grade Levels

ISCS content flow

Grade 9 (Level Three)
In the ninth grade, the student uses his accumulated repertoire of concepts and skills to perform extended investigations of problems drawn largely from the biological and earth sciences. The student is given ample opportunity for individual experimentation on topics of his own choice. Organized as a series of separate units or "instructional blocks," the ninth-grade course offers the teacher maximum flexibility in planning a program suited to student needs and curriculum requirements.

Grade 8 (Level Two)
The organizing themes for Grade 8 are "Matter, Its Composition and Behavior" and "Model Building." In this course, the student finds that although the basic structure of matter cannot be observed directly, a very useful picture—a model—can be deduced b- aking a few logical assumptions. He then discovers the mode as developed to be a very useful tool for interpreting physical, chen and biological situations, both in the laboratory and in nature.

Grade 7 (Level One)
The content of the seventh-grade course is organized around the twin themes of "Energy, Its Forms and Characteristics" and "Measurement and Operational Definition." As the student learns to think in operational terms and becomes aware of what it means really to measure something, he discovers a series of relationships that leads him to the concept of energy and reveals the tremendous power of this important idea.

Cost of Materials to User

The cost of the four texts are: the student text, $4.95; the teacher's edition, $5.97; the student record book, $1.65; and the teacher's edition of the record book, $2.16. The student text could be shared, but the student record book is expendable; thus, the cost of texts for a class of 30 students would vary depending on how the student text was distributed. The cost of the equipment for each grade level is $788 for the classroom kit and $29.70 for each class section supplement. The classroom equipment kit consists of all the materials necessary for up to five classes of 30 students each, meeting at different periods; the class section supplement contains mostly expendable items. Total cost per student for the initial year, thus, would be about $9.00, based upon five classroom sections of 30 students each. Costs for one classroom of 30 students are relatively high, inasmuch as the classroom kit contains sufficient equipment for up to five class sections.

Procedures For Using Product

Learner Activities

Students using ISCS materials study science in basically the same way scientists do--by conducting their own investigations of problems that grip their interest. Each student proceeds at his own pace through a sequence of activities specially planned for him without the necessity of adhering to a uniform learning rate. The student is helped to develop necessary skills and understandings before engaging in extensive free inquiry. The seventh-grader at first receives considerable guidance in conducting his investigations; as he proceeds through the course, he is gradually left more on his own. The eighth grade course offers further opportunities for independent inquiry, while introducing new concepts through sequenced activities. A significant portion of the ninth grade course is devoted to students' independent, open-ended investigations of topics they have chosen by themselves.

An observer would see the following, if he were to walk into an ISCS classroom:

1. Students are actively doing things--picking up equipment and supplies, performing experiments, discussing results with fellow students, writing or checking problems with their teacher--and the stimulus for doing them for the most part comes from themselves and their materials rather than from their teacher.

2. The activities the students are doing are mostly "thing-centered"--they observe phenomena and explain what they have seen.

3. Most students are carrying out their activities either individually or in small groups and very little large-group instruction is evident.

4. Various students are simultaneously carrying out quite different activities and the pace at which they are being taught quite obviously varies with their interest, backgrounds, and abilities.

5. The classroom is arranged in such a way that the student may locate, obtain, and return materials and equipment by himself and with ease.

6. Not only does the rate at which students proceed vary, but the scope and sequence of activities that each student does varies as well.

The ISCS materials provide the student with a blueprint of the way to proceed through a series of correlated activities. They also help him to interpret what he sees and to evaluate his own work. The student works independently.

The developers of the ISCS materials assumed that the students will try to solve any well described problem, regardless of the subject matter, provided that the problem is posed at the proper level of difficulty. Writers of the materials interspersed frequent questions that call for responses not transparent to the student but which the student feels capable of answering. Because the developers assumed that questions of this sort would make activity-centered materials interesting to the student, the writers could include essential topics that were often considered unmotivating for students. Developers claim that motivation has tended to be high among the students in tryout classes.

Teacher Activities

The developers found it necessary to assume that the average junior high school teacher has had little training in science, and that most of the little training he has tends to be in descriptive biology. They also concluded that the average person teaching science in the American junior high school was either teaching out of the field for which he was trained or would prefer to be teaching at a different level. Finally, they assumed that the average junior high school science teacher tends to focus upon the ability to recall information in determining his teaching objectives and

tends to make little use of hands-on experience. While all of these assumptions tend to render difficult the ISCS aims, those who conceived the design for the ISCS materials decided at the outset that it would be impractical to plan to retrain in any substantial way all of the teachers who would use the program.

Thus, the materials to be produced had to be so simple that a teacher could use them with little or no special training beyond that which could be provided in a teacher's guide. To accomplish this, the desired elements of both the content and instructional procedures were built, as far as possible, directly into the student materials. It was hoped that while the untrained teacher was becoming accustomed to his new role and to the new content to which his students were being exposed, his students could be operating more or less independently. Thus, early drafts of the teacher's guides concentrated upon helping the teacher to organize his classroom and to keep his class running as smoothly as possible. Experience has shown that teachers can successfully implement the ISCS program without extensive formal pretraining. However, as dissemination of the materials increases, the developers recognize the need for more intensive retraining for the teacher.

A number of summer institutes and in-service classes are projected for teacher training. These are presented locally with school system support, or may be in the form of an NSF summer program or CCSS project. ISCS has stated that it will cooperate with any school system in helping to formulate plans for teacher training. The Science Education Department of the College of Education of Florida State University has developed a college credit course to train ISCS teachers. This is available to school systems. In addition, preschool orientation sessions are used. The center meeting plan, used throughout the year, has proven effective in helping teachers adjust to their new role. New teacher-training manuals are under development and will complement these present activities. Also, a training guide, Preparing the ISCS Teacher, is now available in the experimental edition.

Provisions for Parent/Community Involvement

No provisions for parent/community involvement have been made.

Special Physical Facilities or Equipment

Minimum requirements are a room in which students can do laboratory work that involves (in some cases) the use of chemicals, i.e., a room that has float-top tables, an electrical outlet, and a sink with running water and drain. There should be storage facilities for the laboratory equipment and supplies, arranged so that students can have ready access to them. Space for the storage of text materials is also desirable.

Recommended Assessment Techniques for Users

To determine how well the students are doing, student self-tests designed to reflect the behavioral objectives (which are not yet available to the user) of each course are perhaps the most effective means available to the user. After completing the work in each chapter, the student checks his own progress by completing a series of questions and activities. Then, using the answer key furnished, he scores himself on the test. A teacher's guide for this self-evaluation is also furnished. These self-tests are not intended for student grading but only for evaluation by the student of his own progress. ISCS is developing resource test questions for each grade. In addition, most teachers have used their own tests.

ORIGINS

Key Personnel

From the beginning, there has been a nucleus of about a half-dozen key people who gave continuity to the project and kept it running smoothly. Dr. Ernest Burkman, the director of the project, was the man who originated the idea for the science program and directed its development. The other key personnel included: the associate directors, Dr. D. R. Redfield, feedback and evaluation, and Dr. W. R. Snyder, teacher education; Dr. S. Darrow, field trials; Dr. J. A. Hathway, production; and Dr. B. A. Conlan, evaluation.

The size of the ISCS staff fluctuated to meet production requirements. For example, during writing conferences and other heavy production periods, the staff was considerably augmented. For each writing conference, a large pool of secretarial help was needed to handle the rough drafts and to prepare the final mats. Student assistants were used to handle local reproduction and dissemination functions. Each group of specialists within the

staff (editorial, art, administration, evaluation, writing materials, etc.) varied in size to meet the week-by-week requirements. In all, about 120 people, including secretaries and graduate assistants served on the ISCS staff from 1966 to 1970.

Many non-ISCS staff personnel made significant contributions to the development of the program. This group included the 150 distinguished scientists, teachers, and educational specialists who either participated during the writing conferences or who met regularly to review policy and to offer guidance as to content selection and organization, pedagogical style, and evaluation.

Sources of Ideas for Product*

In the early 1960's, it was becoming increasingly voiced that what happens between the ages of 11 and 15 is pivotal to a child's ultimate view of science and the natural world. During this period, most youngsters move from a preoccupation with the immediate and concrete, toward thinking more conceptually. Concepts are at the heart of science, and it is at this point in their development that most children gain the ability to study science in an organized way. Here, too, most students make the commitment for or against science as an interest or as a vocation. Whether science comes to be viewed with fascination and intrigue, or with fear and trepidation, and whether or not children make a smooth transition from concrete to abstract ways of viewing their world, seem strongly related to what happens to them in the middle school years.

The developers of the ISCS science program subscribed to the above and point out that, paradoxically, the children at this critical age have been the ones least affected by the recent effort to produce new science instructional materials. Initially, all of the new work focused on the high school. At that time, there was little concern about a K-12 integrated science program; people wanted to see better scientists enter college. The political climate was not right for elementary or junior high school curriculum work in science. The next thrust jumped way down to kindergarten and missed the intermediate level entirely. Although a small number of

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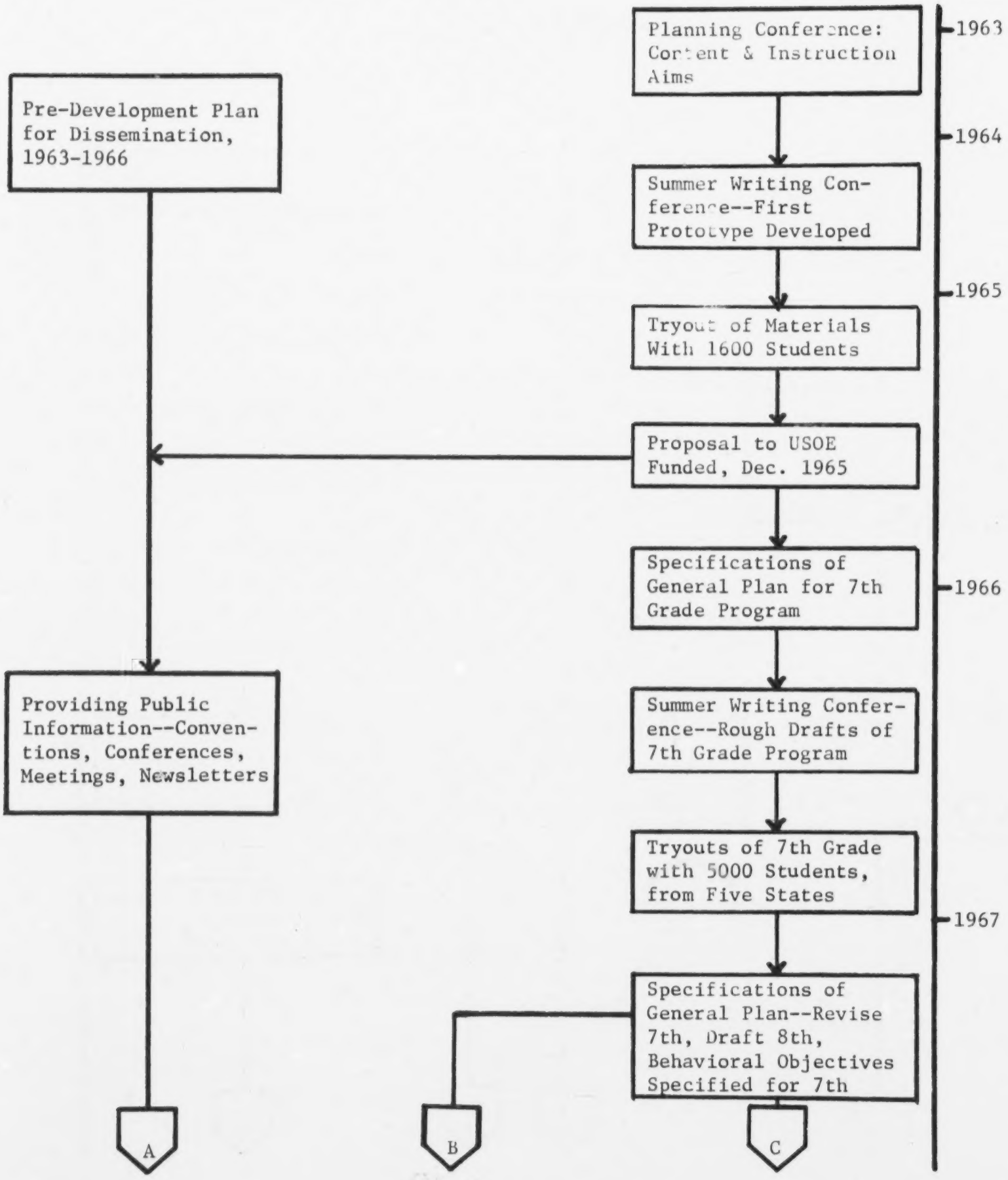
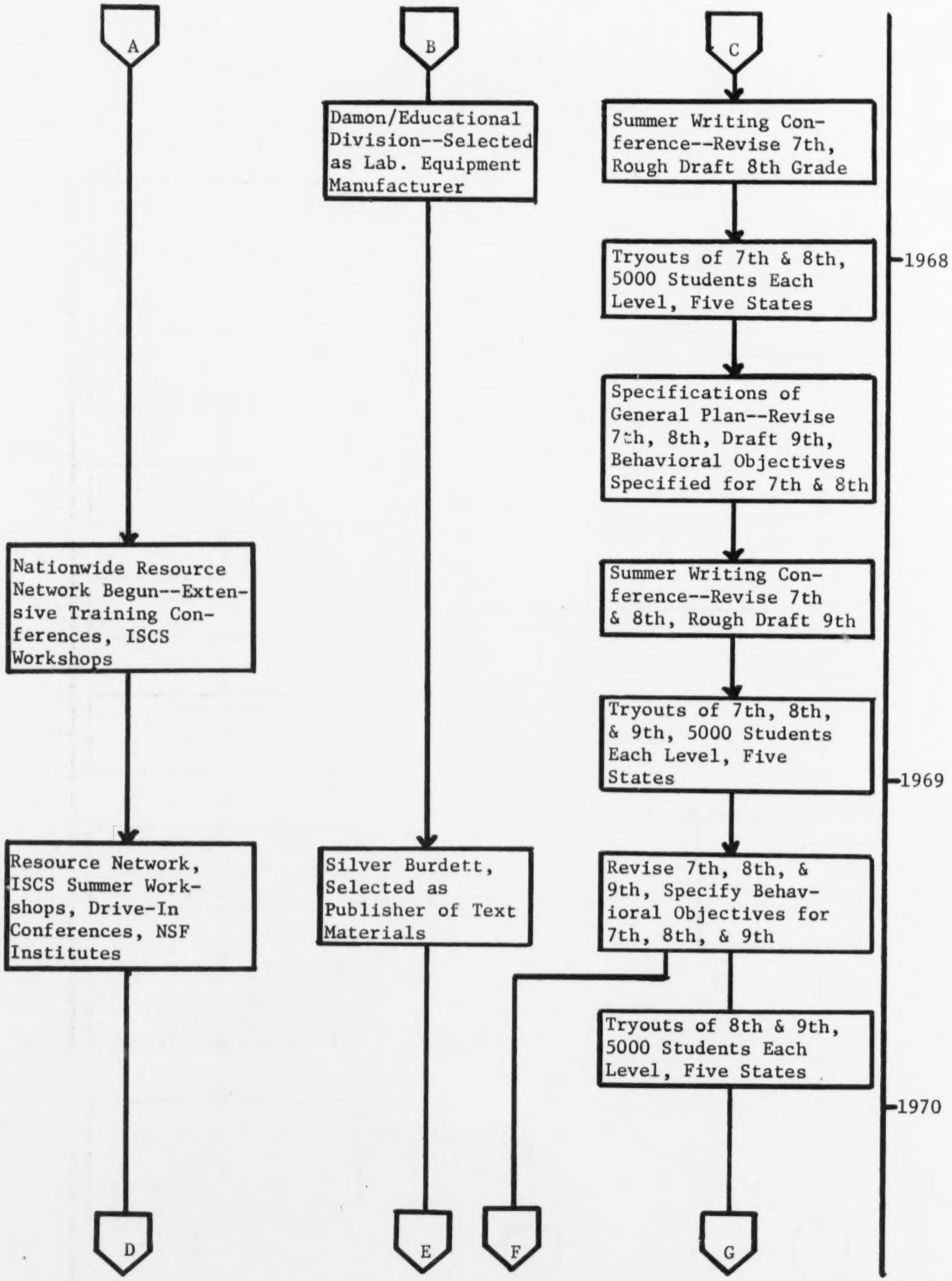
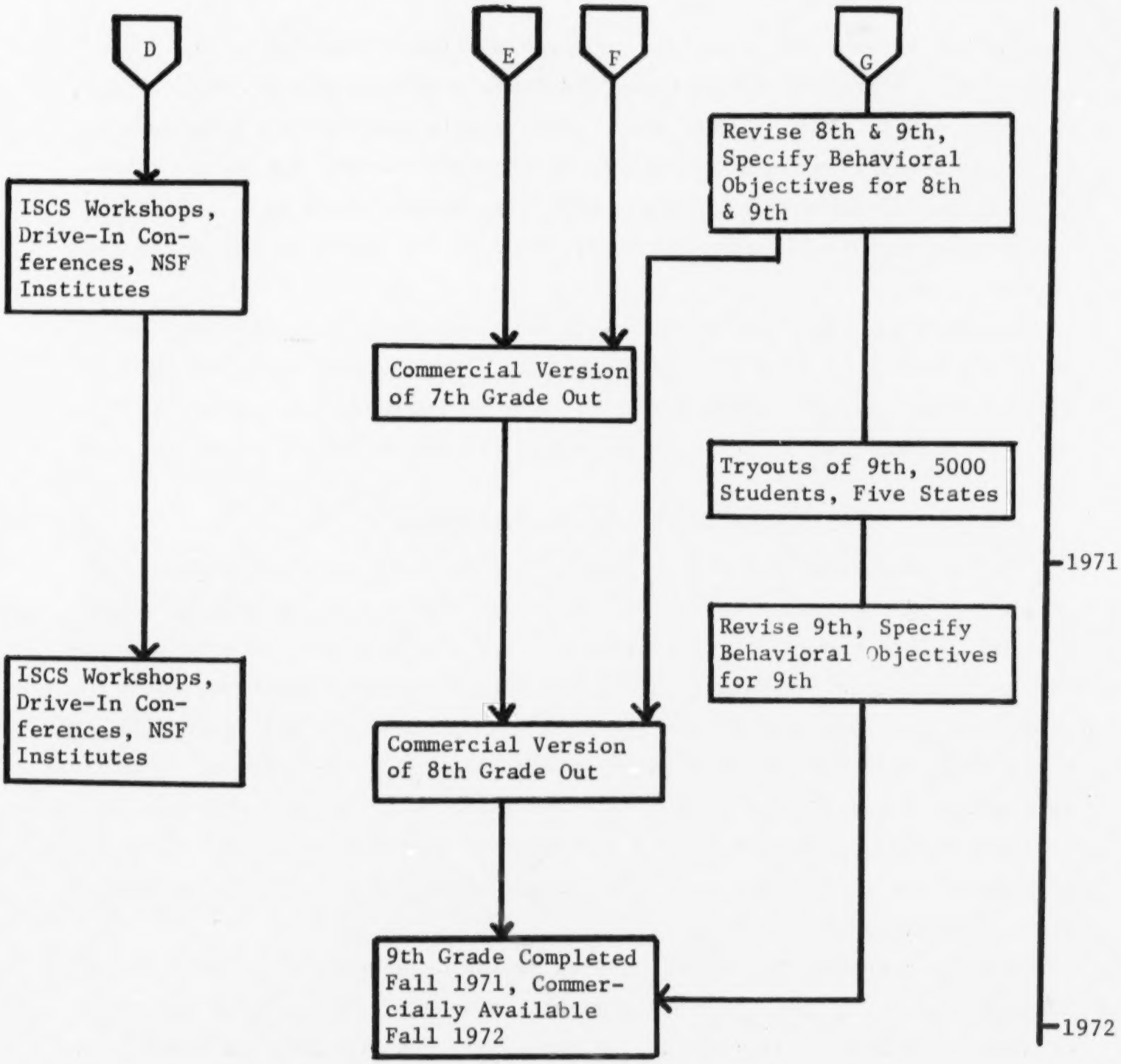
* Figure 4, starting on the next page, notes the major events in the history of the product.

Figure 4

Major Event Flow Chart


Pre-Development Plan for Dissemination, 1963-1966
Planning Conference: Content & Instruction Aims
1963
Summer Writing Conference--First Prototype Developed
1964
Tryout of Materials With 1600 Students
1965
Proposal to USOE Funded, Dec. 1965
Specifications of General Plan for 7th Grade Program
1966
Providing Public Information--Conventions, Conferences, Meetings, Newsletters
Summer Writing Conference--Rough Drafts of 7th Grade Program
Tryouts of 7th Grade with 5000 Students, from Five States
1967
Specifications of General Plan--Revise 7th, Draft 8th, Behavioral Objectives Specified for 7th
A
B
C


A
B
C
Damon/Educational Division--Selected as Lab. Equipment Manufacturer
Summer Writing Conference--Revise 7th, Rough Draft 8th Grade
Tryouts of 7th & 8th, 5000 Students Each Level, Five States
Specifications of General Plan--Revise 7th, 8th, Draft 9th, Behavioral Objectives Specified for 7th & 8th
Summer Writing Conference--Revise 7th & 8th, Rough Draft 9th
Tryouts of 7th, 8th, & 9th, 5000 Students Each Level, Five States
Revise 7th, 8th, & 9th, Specify Behavioral Objectives for 7th, 8th, & 9th
Tryouts of 8th & 9th, 5000 Students Each Level, Five States
1968
1969
1970
Nationwide Resource Network Begun--Extensive Training Conferences, ISCS Workshops
Resource Network, ISCS Summer Workshops, Drive-In Conferences, NSF Institutes
Silver Burdett, Selected as Publisher of Text Materials
D
E
F
G


D
E
F
G
ISCS Workshops, Drive-In Conferences, NSF Institutes
Commercial Version of 7th Grade Out
Revise 8th & 9th, Specify Behavioral Objectives for 8th & 9th
Tryouts of 9th, 5000 Students, Five States
1971
Revise 9th, Specify Behavioral Objectives for 9th
ISCS Workshops, Drive-In Conferences, NSF Institutes
Commercial Version of 8th Grade Out
9th Grade Completed Fall 1971, Commercially Available Fall 1972
1972

commendable efforts had been made to improve science teaching in the junior high school, virtually all of these had dealt with a single science subject or with a single grade. Until about 1963, little progress had been made toward an overall approach to science instruction for the age level. Thus, in American science education the junior high school stood as a weak link between the rapidly changing elementary schools and the recently revitalized high schools.

In 1963, five or six different groups across the nation initiated some action to meet this need for change in junior high school science. Most of these efforts, however, were not focused on an integrated 7-9 effort; ISCS was the only approach that began by looking at all three grades at one time.

Evolution of Ideas for Product

The developers of the ISCS believed that it would be short-sighted and unwise to fill the gap between elementary and high school by writing another textbook. They knew that the content and the teaching methods were changing and would continue to change. Thus, the need for experimentation that would extend present knowledge of the instructional process as well as fulfill the short-range need for improved instructional materials was apparent to the developers of the ISCS program. This was in the early 1960's and they actually already had begun to focus on student-centered materials; hence, to pioneer the incorporation of individualization into their science program was a natural addition.

The key personnel had been involved in the developmental efforts that focused on K-6 and 10-12 science programs, and were familiar with the state of affairs in science education. Dr. Marshall, now President of Florida State University, and Dr. Burkman, director of the ISCS, were the major designers of the 7-9 integrated science program, and used their familiarity with the trends in science education to push this idea into reality.

Early conferences were held to examine (1) what should be taught in science at grades 7-9, and (2) what changes in instruction could be incorporated. These conferences, in actuality, centered largely upon content. General agreement was obtained as to what science content should be taught. Dr. Burkman pushed for changes in instruction that would enable the students to travel through different sequences. Thus, efforts to individualize instruction of the new science program obtained early impetus.

Funding for Product Development

Funds for the development/evaluation/dissemination of the ISCS program have come from three sources: Florida State University, the National Science Foundation, and the U.S. Office of Education. Prior to 1966, early efforts to develop ideas and materials and to try them out in the classroom were primarily supported by funds from the university. From 1966 through 1970, financial support came from the NSF and the USOE. From 1970 to the present, funds have come only from the NSF.

Developers stated, quite emphatically, that funds could not be analyzed to indicate how much was spent for development, how much for evaluation, and how much for dissemination. They pointed out that quite frequently the same activity served more than one of these purposes and, quite frequently, all three purposes. Similarly, funds were not broken down in terms of personnel vs. materials vs. overhead, etc. The following is the only available analysis of funds. It is in terms of source or funding agency.

Funding Agency	Amount
Florida State University	$ 500,000
National Science Foundation	800,000
U.S. Office of Education	1,700,000
Total	$3,000,000

PRODUCT DEVELOPMENT

Management and Organization

The ISCS is housed on the Florida State University campus and is an activity of the College of Education. While the continuity for ISCS has been provided by a small permanent staff directed by Dr. Burkman, much of the work of the project has been carried out by scientists and teachers from all over the United States. The input of these scientists and teachers has been made, under varying degrees of control or direction of the key ISCS staff, through the following: Regional VIP conferences, drive-in conferences, summer writing conferences, teacher education conferences, behavioral objectives conferences, orientation conferences, ISCS summer workshops, NSTA conferences, NSF summer institutes, and NSF summer conferences.

Original Development Plan

The original development plan was tried out during an informal writing conference held during the summer of 1964 at, and funded by, Florida State University. The philosophical intent, which described the type of content and instruction desired, had been well delineated. As Dr. Burkman expressed, at this point there was no sense in any further philosophical framework; they needed to know if what they were philosophizing could be done. This was the purpose of this 1964 summer conference.

Developers were quite concerned about how they should organize the people for the task; they needed many people with many skills. They decided not to pull people off their jobs as "good people are always busy and you can't separate them from their work." Consequently, they chose the summer conference approach.

During the 1964 summer conference, a group of writers were assembled to produce materials that were to be qualitatively similar to the ones that today comprise the ISCS. The participants in the conference began their work guided by a conventional systems design; that is, they planned to first identify objectives toward which materials would be directed, then develop materials, then develop evaluation instruments, and finally, try out the materials. For the first several days of the conference, the morale of the writers was quite obviously low, and at the end of the first week of the four-week conference, no progress had been made. When quizzed as to their lack of progress, the writers reported that they found it extremely difficult to prestate objectives and that they felt uncomfortable trying to do this. They were convinced that progress would continue to be slow as long as they were required to write objectives before developing materials. In fact, some writers, in utter frustration, explained, "I'm a creative person, let me produce something first, and then you write what it will do."

In general, these writers, who were knowledgeable with respect to science, tended to object on two grounds to being required to prestate specific objectives. First, they felt that it is impossible to know in advance what they seek to accomplish with science instructional materials, and even if it were possible to make such a prediction, much of what good science instruction is aimed at accomplishing cannot be stated in specific terms. Second, science content specialists felt that prestating specific instructional objectives tended to be unduly constraining and reduced their perspective.

At this point, the developers could either (1) train the writers to write objectives or (2) modify the systems approach. The developers felt that content specialists were an essential part of the development team, and that recruiting individuals with this kind of capability and getting them to work productively would be extremely difficult if the group tried to apply a conventional systems model. The critical test was whether the materials could be produced. It was decided to abandon the systems approach and have the writers immediately produce, under general guidelines, the instructional materials. Shortly after this decision was made, there was a burst of productivity, and a considerable quantity of instructional materials were turned out during the remaining three weeks of the conference.

Modifications of Original Development Plan

The conventional systems design approach or instructional design procedure was thus tried and then critically modified. The new approach included the following steps in order:

1. Specification of general plan.
2. The production of prototype materials with questions for students interspersed among the materials--these questions later became cues for writing the behavioral objectives. Consequently, the first interplay was between materials and questions rather than objectives and materials.
3. Tryout of materials using only "intuitive tests"--specifications of what the developers thought the children should know after exposure to the materials and activities.
4. Development of evaluation instruments and formal objectives and formal tryout of materials.

The new approach, then, postponed the writing of objectives until the developers found out what content people could write, children could do, and the schools could tolerate. Only after they could answer "yes" to "Will it fly in the classroom?" did they concern themselves with "What specific things are the students learning?"

Although there were certain disadvantages to this approach, it proved critical in maintaining a production schedule. The finished product was to include all of the ingredients that would have been produced had the traditional systems approach been successfully implemented; that is, the

finished product includes objectives, materials for the objectives and evaluation instruments to measure student progress before and after using the materials. It must be pointed out, however, that the developers never intended to produce a complete set of behavioral objectives. Much of ISCS educational intent is affective, which the developers felt cannot be stated in behavioral terms. They simply stated that they have a group of objectives that are in behavioral terms and that their materials can accomplish; they also note that about 50% of their objectives will not be and, they feel, never could be put in behavioral terms.

In summary, the new approach avoided the "wheel spinning" reported by others attempting to verify objectives as a first step, and it may have allowed more important objectives to be built into the materials.

Actual Procedures for Development of Product

Development

The general process for developing instructional materials was to quickly produce draft materials that met the assumptions agreed upon in advance. On the basis of field tests in the classrooms of schools around the country, revisions were made until the materials were demonstrated to work. For the most part, the draft materials were produced during very intensive summer writing conferences while the academic years were used for testing and evaluation.

As noted earlier, under local funding, the project began to develop learning materials at the seventh grade level. This activity started in the summer of 1964 and served to establish the rationale which had emerged from earlier planning conferences. Three sequences, including written materials and equipment, were produced during this 1964 summer writing conference and tested during the following academic year. After these first prototype materials were developed and tested, the developers could tentatively state that (1) rough materials could be produced and (2) there were good indications that such materials could be used successfully in the classroom.

Having established a workable model, the developers sought and obtained financial support from the USOE in the winter of 1965-66 to produce the 7-9 curriculum. The next writing conference was held during the summer of 1966. The writing team at this conference produced the prototype seventh grade

course which was tested during the 1966-67 school year. During the next writing conference in the summer of 1967, the writing team completely revised the seventh grade materials, and developed a set of eighth grade materials that were tested during the 1967-68 school year. The group that worked during the summer writing conference of 1968 revised both seventh and eighth grade materials and created the first draft ninth grade materials that were tested during the 1968-69 school year.

Each of the summer writing conferences lasted eight weeks; during this time about 40 staff members (junior high school teachers, education specialists, evaluation specialists, and production people) completely reviewed previously developed materials, developed a complete set of materials for the next grade level, edited and illustrated the materials, developed equipment kits, developed instruments to measure pupil progress, and reproduced materials in sufficient quantities to allow each level to be tried with about 5,000 students.

The organizational patterns for these conferences can be described as follows. ISCS project staff: (1) summarized the feedback collected during the previous academic year; (2) made tentative decisions as to the steps that should be taken to make the necessary modifications; and (3) sent this information, plus several descriptive documents illustrating possible ways to modify previously developed materials and to develop the new materials, to conference participants before they were scheduled to arrive. The writing conference, itself, followed a very stringent schedule of writing, revising and editing materials and developing equipment specifications to accompany the materials. The editorial process employed during the writing conference was fairly sophisticated and required the production staff to work intensively beyond the formal close of the writing conference, so that the materials would be ready for fall tryouts.

While the project found it advantageous to use summer writing conferences to develop the early drafts of its materials, it appeared more efficient to have one or two project staff members or outside consultants make the final revisions of the materials for each of the three grade levels. Thus, the writing conference provided the best means for quickly producing large amounts of rough draft material, but were not as useful for doing careful revision of existing materials.

The first revisions of the materials for each grade level were made from data collected from evaluative instruments built on the basis of intuitive judgments by the project staff members. Beginning with the second revision, however, the results obtained from performance objective-based tests, which the students gave to themselves at the end of each chapter, were used to make necessary adjustments. The objectives upon which ISCS based these tests were obtained by project staff members who analyzed the draft materials, and then put into formal performance statements the objectives they deduced from the materials. This process was simplified by the fact that the writers had been asked to intersperse questions at frequent intervals to help the students to ascertain whether or not they had understood what was intended.

Formative Evaluation

The instructional materials had been scheduled to undergo three full field trials with four annual revisions. The four years include one year after the last trial edition, during which the commercial edition is produced. Since the commercial editions of the eighth and the ninth grade materials will not be available until the fall of 1971 and the fall of 1972, respectively, some formative evaluation activity remains.

ISCS found that it was generally inappropriate to use an evaluative strategy in which the formal research designed to test a hypothesis was stated in full form. In its place, techniques were developed to collect from a wide variety of representative sources information which could be processed in a relatively short time. This provided functional input to revision teams, even before the completion of the field trial.

The first formative evaluation activities actually began with the testing of the pilot sequences developed during the summer of 1964. ISCS-developed achievement tests with process and content subtests were employed in a pretest-posttest design to assess student progress. One thousand six hundred seventh grade students in three districts in Florida participated. In addition, teacher feedback and staff visitations provided further information. The general conclusions that resulted were:

1. Activity-centered, individualized instruction remained a promising technique for science instruction.
2. The printed page using a semi-programmed format was an acceptable instructional medium.

3. Teacher orientation and teacher guides were essential.
4. The concept and sequence of the materials were sound.
5. The materials generated a high level of interest.

Field trials of the ISCS materials, following each of the summer writing conferences in 1966, 1967, and 1968 and during the 1969-70 and 1970-71 school years, occurred in two settings: in the Florida State University Computer Assisted Instruction (CAI) Center and in regular classrooms from selected schools in selected states. The rationale for using two such settings was to collect different types of information. The CAI mode of evaluation was included because of its potential for providing a more detailed and continuous record of each student's progress through the entire course sequence. As students of varied ability moved through the computer course, every response made by each student to each step of the sequence was stored. Then, profiles were collected and examined to determine which portions of the sequence needed revisions, elimination or conversion into excursions.

Schools participating in the field trials included rural and inner-city, large and small schools from Florida, Illinois, Indiana, Iowa, and New Hampshire. Students taking the CAI course were from Florida schools and used essentially the same materials, progressed in the same order, and had the same laboratory experiences as students taking the ISCS course in the ordinary classrooms. Because the ISCS materials have a semi-programmed, individualized format and because these materials contain many questions which require a student response, they proved readily adaptable to CAI presentation. The following table shows the number of ISCS students in regular classrooms and in CAI classrooms from whom data was collected.

Table 1

Number of ISCS Students in Regular and CAI Classrooms From Whom Data Were Collected

	1966-67	1967-68	1968-69	1969-70	1970-71
Grade 7					
Regular	4,600	5,030	5,620		
CAI	16	16	20		
Grade 8					
Regular		4,570	4,520	4,450	
CAI			20		
Grade 9					
Regular			2,350	3,200	2,800
CAI				31	

As a frame of reference, data from non-ISCS science classes were obtained to parallel the schedule shown in the above table. This data came from schools in Illinois and Florida and involved nearly 500 students per grade level per year.

During these field trials, formative information was derived from four basic sources: the students, the teacher, the consultant, and ISCS staff members. Each source made a unique contribution. The role of the formative evaluation group was to develop the most useful instruments to use with each source, analyze data returned from it, and develop from each a summary working paper with interpretations for the revision teams. As an important note, it was not uncommon for a consistent response from one source to appear in conflict with that of another.

In addition to the comprehensive data obtained from CAI, the student data courses from both settings included baseline tests, general ISCS achievement tests, chapter-by-chapter performance tests and excursion tests. Baseline tests included: the California Test of Mental Maturity, the Metropolitan Reading Test, the Cooperative Test of Reading, the Metropolitan Achievement Test, and the Test on Understanding Science.

The CAI procedure proved extremely valuable to the overall evaluative effort; the procedure pinpointed: poor wording, places where review was needed, corrections recommended by students, areas where students spent too much time, and areas of high error rate. The greatest yield of this fine-grained, detailed feedback proved, as did the student performance testing source, most valuable in later revision efforts after sweeping changes were no longer being made. The teacher was a most important source of data about how the ISCS program functioned in the classroom; both formal data sheets and informally written reactions or opinions were employed to collect teacher feedback concerning nearly every aspect of the program's use in the classroom.

In addition to the student and teacher data sources, there were three other sources for evaluation utilized by ISCS. They were: the ISCS advisory committee, classroom visitations by ISCS staff members, and meetings between selected ISCS teachers and the authors responsible for revising the instructional material. The suggestions of the advisory committee had particular influence on the early drafts of student materials. Classroom visitations by ISCS staff members were a valuable source of informal

evaluation about the ways the instructional materials were being used in real classroom situations. The selected ISCS teachers who met with the writers critiqued the instructional materials page by page. This system proved to be an efficient method of synthesizing the feedback from many sources and highlighting the particular places that needed revision.

Development of Performance Measures

Several performance measures were being developed as the student materials were being written and revised. The ISCS end-of-sequence achievement test proved to be of least value to the project's formative activity. The problem was not simply one of developing validated and reliable items in the context of an annually changing instructional sequence. More important was the difficulty in using a 35-45 item multiple choice test to provide a substantive basis for change. The Test on Understanding Science (TOUS) was developed to examine the extent to which the instructional program met the objective of instilling an understanding of science, scientists and the scientific enterprise. Student self-tests were developed as a by-product of the formalization of the detailed behavioral objectives for each chapter of instructional material. The motivation for the self-tests grew out of teacher and pupil feedback of individual student performance during the field trial. Test items were selected from the pool of performance objectives to provide direct feedback to the student and the ISCS staff in important terminal behaviors expected by the end of each chapter.

SUMMATIVE EVALUATION

Nearly all of the evaluation efforts thus far conducted have been formative; i.e., they were designed to collect information on what should be done to improve a tentative set of instructional materials. The ISCS staff pointed out that summative evaluation, designed to determine what is accomplished by a set of instructional materials, is normally done after materials have been developed to a level of relative stability and there is a need for a careful description of their effectiveness.

A proposal for funding the evaluation of commercial editions of ISCS materials has been under consideration by the U.S. Office of Education for several years. At this time, it is unlikely that such an evaluation will ever take place.

There are some things that can be said now about the ISCS materials. Comparison of ISCS achievement test means shows improvement for ISCS students for each grade level across successive years of revision. ISCS students also show increasing improvement in performance over non-ISCS students. However, revision of ISCS materials has also necessitated a revision of the ISCS tests. As a result, comparisons of means could be misleading. With this in mind, the individual items used in the 1966-67, 1967-68, and 1968-69 tests have since been classified in terms of both process and content areas. The analysis of student performance on items categorized in this way suggests substantial improvement from year to year. Also, comparisons across years on the unchanged test items show improved student performance. However, as pointed out by the ISCS staff, the transitory nature of the materials makes it impossible to anticipate the substantial changes that may result from subsequent revisions.

The following are several key questions with answers that are based on interim data and which must be viewed as tentative. The Final Report of ISCS, February 1971, presents minimal data on student performance.

1. How is ISCS student performance on ISCS achievement tests related to basic student abilities? The most recent data for beginning- to end-of-year performance on ISCS achievement measures show significant gains for high, medium and low ability students, with the percent gain being higher for the high ability student.

2. How is ISCS student performance on self-tests related to ISCS achievement and intelligence? The success rate on the self-test items favored the high ability group.

3. Do ISCS materials produce changes in student attitudes towards scientists and the scientific enterprise? As indicated by the Test on Understanding Science, they do.

4. To what degree will students taking the ISCS program do well on standardized and state science achievement tests? This largely depends on the type of test. The ISCS student may not do as well on a factual or recall type of science test as a student in a conventional class. On a test that is process-oriented, the ISCS student should do well.

DIFFUSION

Agency Participation

The ISCS staff felt that no factors were more critical to the ultimate utility achieved by a curriculum project than the nature and timing of its decision regarding the diffusion of materials. Their diffusion efforts began when they began development. By the time the commercial publishers were selected, most of the diffusion strategy was well implemented.

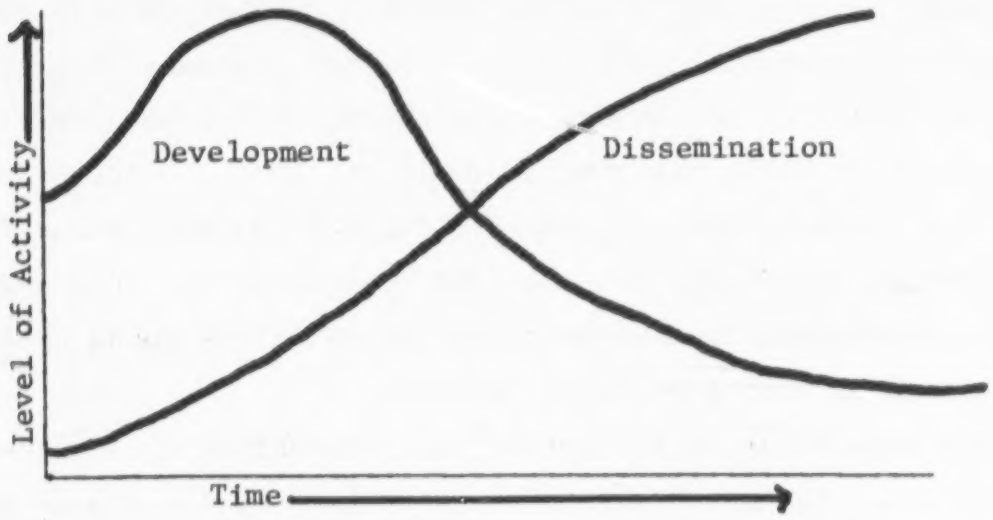
Silver Burdett Company, a division of General Learning Corporation, was selected in 1969 as the authorized publisher of the ISCS text materials. The manufacturer of the ISCS official laboratory equipment is Damon/ Educational Division which has worked closely with ISCS since 1967.

Diffusion Strategy and Efforts

The ISCS approach has been to plan simultaneously its developmental and dissemination strategies and to work on both of these facets of its effort throughout the life of the project. While development of materials was given primary emphasis during the early years and dissemination work became the focus later, at no time in its history did the project completely ignore dissemination activities; this is indicated by the graph in the figure below.

Figure 5

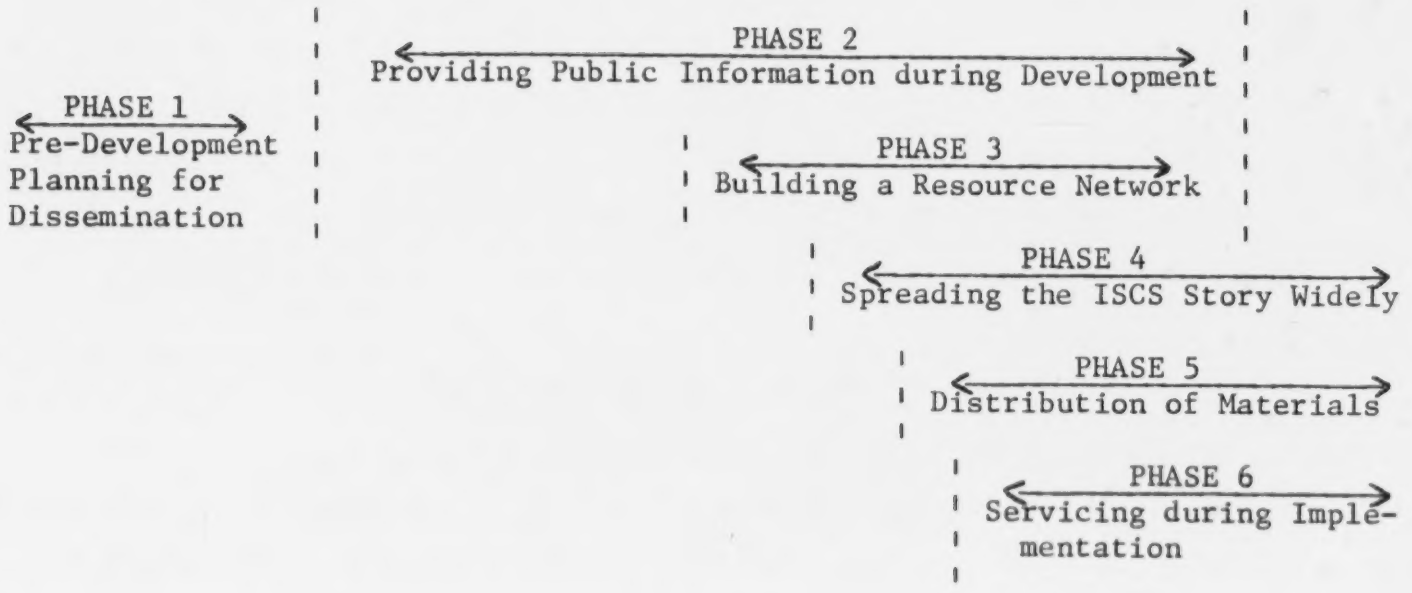
Simultaneous Planning of Developmental and Dissemination Strategies



The ISCS dissemination strategy consisted of six phases as shown in the following figure:

Figure 6

ISCS Dissemination Strategy



As the diagram indicates, the phases were not discrete; they overlapped in time and function. Some are continuing.

A number of decisions, made before the actual development of the ISCS instructional package began, were very important for establishing the ultimate limits within which the materials in that package could be disseminated. It was decided, quite early, that the ultimate package of materials must be realistic with respect to the training of the teachers who must implement it, the abilities of the students who would use the materials, the facilities in the school in which the program would be used, and the status of school budgets for instructional materials. Great pains were taken to assess these matters and to build into the plan for developing the ISCS instructional materials provisions that would allow the materials to be used under the conditions which that assessment revealed.

It was also clear at the outset that mechanisms would have to be established to bring the materials to the attention of the school people, to then distribute the materials to the schools, and finally to help the schools make whatever transitions were required. Decisions that came out of the early

planning included: the project would publish a newsletter; it would only publish what it had done, not what is was going to do; it would involve key people representing many organizations and disciplines in planning and executing its work; it would use a "multiplier effect" in disseminating; and it would conduct a larger field trial than necessary to establish the nationwide network.

The project sought to reach a mixture of decision-makers from all levels--science educators, scientists, supervisors, administrators, and department heads. It was planned that interest in the program would peak about the time the commercial editions of the materials became available. To reach the various groups of people, a series of low-key presentations at conventions, conferences, and educational meetings were conducted. The program was explained and demonstrated, experimental editions were passed out at cost, brochures and newsletters were distributed and orientation sessions were provided for teachers. Also to broaden exposure of ISCS, small numbers of qualified schools were selected in strategic areas and allowed to purchase books and materials from their own funds, and ISCS demonstration centers were established at both supported and independent schools.

When the project concluded that it had developed a demonstrably worthwhile product, it was decided that ISCS should actively seek to build a nationwide network of resource people who could give accurate information about the program and help schools to implement it. In the spring of 1968, Center leaders, teachers in test and independent schools, writing conference participants, and former ISCS project staff members were such resource people. To increase the number of resource people and fill in the nationwide network, three-week intensive training conferences were held; by the end of 1970 more than 300 resource people had been trained. Also during the summers of 1969 and 1970, NSF institutes for science supervisors were conducted. Finally, the ISCS conducted summer institutes during 1968, 1969, and 1970.

To fill the need for some method of spreading the information about ISCS even more widely, "drive-in" conferences were held in 1969-1971. These were conducted by resource personnel at strategic locations across the United States.

To get the materials mass produced and delivered to the schools, the aid of a commercial publisher and an equipment manufacturer was obtained. Much attention was given to the planning and negotiation of selecting the commercial publisher and manufacturer.

In anticipation of the sixth diffusion phase, a first effort at teacher education, called "Preparing the ISCS Teacher," was written in 1970. Other efforts aimed at servicing the schools included: development of teacher guides of development of comprehensive teacher training modules; activities by the publisher to maintain and stimulate interest in the ISCS program; and encouragement and support of other universities that plan to run ISCS institutes.

Still to be completed are the following dissemination activities: development of the teacher education modules; more in-service teacher training institutes; more pre-service teacher training; and the granting of more funds to school districts to purchase the program.

Product Characteristics and Diffusion

ISCS developers aimed at a product that fell somewhere between very ideal/unuseable and same old thing/useable. If they tended to lean one way, they were more conservative. They wanted to make certain their program would have impact, and to have impact it had to be useable in today's classrooms. Thus, the acid test to the developers was not the brilliance of their conceptual scheme, but whether or not their program would be widely accepted. In short, the developers realized that they had to compromise their instructional package to make it disseminable. In fact, Dr. Burkman points out that more good materials are in his closet than in the final product, largely because of cost factors.

As noted earlier, the developers designed their program to be realistic with respect to the training of the teachers who must implement it, the abilities of the students who would use the materials, the facilities in the schools in which the program would be used, and the states of school budgets for instructional materials. Consideration was given to nearly every critical variable that would affect how the final product would be accepted; how the product would be compatible with other innovations, for example, modular scheduling. Most importantly, once these matters were assessed, provisions were built into the development plan to allow the materials to be used under the conditions which the assessment revealed. The following are some of the limitations imposed by the developers:

1. Equipment kits had to be complete and useable by a typical class of 30 students.
2. The activities had to be practical for a class of 30 students operating in a 45-minute time period.
3. The program had to be useable in an ordinary classroom with one electrical outlet, one sink and flat-top tables.
4. The instructional materials had to fit the provisions of most state textbook adoption criteria.
5. The program had to be useable by a teacher whose training in science was minimal and who had no specialized training in implementing individualized instruction.
6. The final package had to be practical from a commercial point of view.

ADOPTION

Extent of Product Use

Over 200,000 students from rural and inner-city and large and small schools in every state in the Union are presently using the ISCS program. These students have a wide range of abilities and come from all steps on the socioeconomic ladder. In most cases, the diffusion activities planned by the developers were the primary facilitators of the adoption process.

ISCS materials are also now in use in Australia and in American dependent schools in Germany. Experimental testing of the materials is now under way in Manila, and plans have been established for a joint Florida State University-Philippines effort to produce a special Philippines version of the program. In addition, project personnel have visited Japan, India, and several South American countries for preliminary discussions related to possible use of the materials in these countries.

Installation Procedures

As noted earlier, the ISCS program was designed to be compatible with the present day classroom procedures. All equipment is provided, no physical arrangements have to be made, classroom reorganization is unnecessary, staff requirements are not increased, and teacher training has been minimized. However, the developers have learned that they underestimated the need for teacher training. Some teachers, accustomed to being the dominant figure in an information-centered classroom, have not been able to establish a

classroom environment conducive to inquiry, to individualized learning, and to self-evaluation. As the program became generally available, opportunities for learning about ISCS increased. This year, 25 NSF summer institutes, cooperative college-school science programs (CCSS), summer conferences, and leadership conferences involving ISCS are being held. ISCS is also presently launching a new set of teacher education materials to help the teacher effect the metamorphosis necessary to conduct an ISCS classroom.

FUTURE OF THE PRODUCT

On the basis of scope criteria, i.e., extent of use in the classroom, the ISCS program is already having a significant impact. It is quite likely that use of this program will continue to grow for two specific reasons: (1) the dissemination strategy employed by the developers has demonstrated its effectiveness; and (2) the ISCS program is the only integrated, innovative science program that bridges the gap between modern elementary science programs and modern high school programs in biology, chemistry and physics. On the basis of the criteria of effectiveness, tentative summative evaluation findings reported by the developers suggest that the program is doing what it was designed to do. A more formal summative evaluation might clarify these findings and ascertain the product's potential for impact in terms of effectiveness.

The most significant extension of the ISCS project is the launching of teacher education materials designed to help the teacher establish a classroom environment conducive to individualized learning, to inquiry, and to self-evaluation. Still in the experimental stage, these materials show a generalizability to teacher training for other individualized instruction programs, in other content areas, and at other grade levels. The rationale underlying this effort permits the working group to follow a conceptualized approach to teacher education as they make the plan operational. The materials will be explicit, allowing each teacher to proceed through them at his own pace, varying the scope and sequence to fit his own needs. They will resemble the present ISCS student materials, having a core that all teachers should complete and numerous excursions to meet a variety of individual needs. The teacher educator's role will be advisory, and in those cases in which no teacher educator is available, teachers will be able to use the materials for self-instruction.

CRITICAL DECISIONS

The following events are a fair approximation of the crucial decisions made in the five year developmental history of the Intermediate Science Curriculum Study which produced Probing the Natural World. For each decision point, the following information is described: the decision that had to be made, the alternatives available, the alternative selected, the forces leading to the selection of a particular alternative, and the consequences resulting from the selected alternative.

Most of the critical decisions to be discussed were related to the strategy employed to make certain the program would operate successfully in typical classrooms. Although an attempt has been made to present the critical decisions or turning points in chronological order, it must be emphasized that these decisions were not made at one point in time, nor did they necessarily lead to the next decision presented in the sequence.

Decision 1: To Focus on an Integrated Effort

The early efforts to update science education were first aimed at high school and then at elementary school; the junior high school was missed. In 1963, five or six different groups across the country initiated action to meet the need for change in junior high school science. Most of them were focused on either a single science subject or a single grade level. ISCS decided to develop an integrated effort which would fill the entire gap between high school and elementary school. While this effort required extensive resources in terms of talent and money and time, it resulted in the production of the only integrated science program for the junior high school grades. Consequently, its adoption by users has been significant and continues to grow at a significant rate.

Decision 2: To Incorporate Individualization

In the early 1960's the key ISCS personnel were already thinking "individualization." They were aware of the history of this trend and had actually done some work themselves on student-centered materials. They knew that teaching methods and learning procedures were changing. They could have ignored this trend as did many curriculum projects initiated in the 1960's, but instead they sought to pioneer. Now the product is

commercially available, and schools all over the nation are using it to individualize their science programs. The ISCS program with its individualized approach meets this present-day need and consequently is proving attractive to users.

Decision 3: To Plan for Dissemination Very Early

Instructional design projects are often completed in two steps--development first and then dissemination. Others do the opposite--they broadcast their efforts widely and soon, and terminate dissemination when development terminates. ISCS developers felt that these procedures are typically employed because of poor planning for dissemination. ISCS decided to employ a strategy for dissemination which called for extensive pre-development planning. Dissemination was to start slowly as development was speeding ahead; then, as development slowed down, dissemination would increase, thus ending with little development activity and extensive dissemination activity. This decision to plan for dissemination and to include dissemination activities throughout the history of the project paved the way for making subsequent critical decisions about characteristics of the final product. It also primed potential users for adopting the product.

Decision 4: To Produce a Realistic Package

During the planning for dissemination, developers had to come to grips with just how idealistic they could be and still have assurance that their product would be accepted in the classroom. They decided to compromise their instructional package. The package would be realistic with respect to ordinary teachers, ordinary students, ordinary school facilities and ordinary school budgets. Consequently, as Dr. Burkman reminisced, more good materials were left in his closet than in the final product. However, this decision, which did not present the incorporation of the latest ideas in science education or individualization, did make the product commercially attractive; users could afford it.

Decision 5: To Involve Many Key People Representing Many Disciplines

The ISCS staff views the United States educational system as being designed to prevent programs from having impact. This may prevent bad programs from being implemented and assures that only well accepted programs

will have impact. Thus, the ISCS developers viewed the educational system as consisting of "blockers" which had to be removed. They decided that the best way to remove these blockers was to get them into the act! For example, scientists helped in the development. Every relevant group, including taxpayers, school budget officers, unions, subject coordinators, administrators, teachers, and instructional designers, was represented. Credibility was increased: developers could point to an involved representative of each group with "blocker potential."

Decision 6: To Alter the Systems Approach

The first five decisions, noted above, were all made prior to any development activity; while these decisions were continually reassessed, their impact occurred prior to any production of materials or equipment. Development activity was initiated in 1964 at the first summer writing conference. A conventional systems design approach was to guide the developers and the writers. That is, they planned to first produce objectives toward which materials would be directed, then develop materials, develop evaluation instruments, and finally try out the materials. This approach did not work. As Dr. Burkman pointed out, the instructional system design theorists and the content specialists who do the actual instructional development always, when they get together, came to blows. The writers, who were content specialists, could not write behavioral objectives before writing the student activities. Instead of "retraining" the writers, the ISCS decided to be responsive to the people and modify their systems approach. With the new approach, a general plan was first specified, then materials were developed, then the materials were tried out, then objectives and formal evaluation instruments were developed, and finally, the materials were formally tried out. The developers were convinced that had the typical systems approach been maintained, the first prototype and subsequent versions of the product would never have been developed. However, it must be pointed out that, although commercial editions of the materials are available, the behavioral objectives that the developers claim they specified are still only for "in-house" use and are not available to users.

Decision 7: To Build a Nationwide Network

When the developers felt they had developed a demonstrably worthwhile product (about 1968), they decided to actively seek to build a nationwide network of resource people who could give accurate information about the program and help schools to implement it. To supplement the already available resource people, namely the Center leaders, teachers in test and independent schools, writing conference participants and former ISCS staff members, three-week intensive training conferences were held to train more resource people. This training effort, along with the NSF institute and the ISCS summer institute, have made it possible to have a resource person within driving distance of every science teacher in the country.

Decision 8: To Reassess the Need for Teacher Education

ISCS developers decided quite early to minimize teacher education, by making certain that the product could be successfully used by a typical teacher. They learned, however, that many teachers could not establish a classroom environment conducive to inquiry, to individualized learning, and to self-evaluation. Recognizing a need for more teacher training, the developers are launching a new set of teacher education materials designed to assist the teacher in establishing a classroom atmosphere appropriate for ISCS classrooms. Still in development, these materials show a generalizability to teacher training for individualized instruction programs in other content areas and at other grade levels.

APPENDIX A

LIST OF PRODUCTS AND DEVELOPERS

The following is a list of products for which Product Development Reports will be prepared.

1. Arithmetic Proficiency Training Program (APTP)
   Developer: Science Research Associates

2. CLG Drug Education Program
   Developer: Creative Learning Group
   Cambridge, Massachusetts

3. Cluster Concept Program
   Developer: Dr. Donald Maley and Dr. Walter Mietus
   University of Maryland

4. Developmental Economic Education Program (DEEP)
   Developer: Joint Council on Economic Education

5. DISTAR
   Developer: Siegfried Engelmann & Associates

6. Facilitating Inquiry in the Classroom
   Developer: Northwest Regional Educational
   Laboratory

7. First Year Communication Skills Program
   Developer: Southwest Regional Laboratory for
   Educational Research & Development

8. Frostig Perceptual-Motor Skills Program
   Developer: Dr. Marianne Frostig

9. Hawaii English Program
   Developer: Hawaii State Department of Education
   and the University of Hawaii

10. Holt Social Studies Curriculum
    Developer: Dr. Edwin Fenton
    Carnegie Education Center
    Carnegie-Mellon University

11. Individually Prescribed Instruction--Math
    Developer: Learning Research and Development Center,
    University of Pittsburgh

12. Intermediate Science Curriculum Study
    Developer: Florida State University
    Dr. Ernest Burkman

13. MATCH--Materials and Activities for Teachers and Children
    Developer: The Children's Museum
    Boston, Massachusetts

14. Project PLAN
    Developer: Dr. John C. Flanagan and the
    American Institutes for Research

15. Science: A Process Approach
    Developer: American Association for the Advancement
    of Science, Commission on Science Education

16. Science Curriculum Improvement Study
    Developer: Dr. Robert Karplus, Director
    University of California, Berkeley

17. Sesame Street
    Developer: Children's Television Workshop

18. Sullivan Reading Program
    Developer: Dr. M. L. Sullivan

19. Taba Curriculum Development Project
    Developer: San Francisco State College

20. Talking Typewriter
    Developer: Omar K. Moore and Responsive
    Environments Corporation

21. Variable Modular Scheduling
    Developer: Stanford University and
    Educational Coordinates